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Economics of Controlling Sediment from Irrigation

An Idaho Example

Richard Magleby
James Kasal
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Abstract

The Rock Creek, ID, project of the experimental Rural Clean Water Program may improve recreational fishing and hunting, reduce costs of removing sediment from irrigation ditches, and slightly lower the cost of hydroelectric plant maintenance. The project is also providing cost, tax, and long-term yield benefits to farmers. Total economic benefits, including onfarm benefits, may exceed costs, but water quality benefits alone may not unless substantial additional implementation of conservation tillage occurs among program participants. Conservation tillage is the most cost-effective practice, while improved irrigation structures are the least cost effective.

Keywords: Idaho, Rural Clean Water Program, nonpoint pollution control, soil conservation, economic evaluation, benefits and costs, cost-effectiveness.

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Summary

The Rock Creek, ID, project of the experimental Rural Clean Water Program was one of five projects comprehensively evaluated to provide insight into designing and implementing future nonpoint pollution control programs. The economic evaluation presented in this report focuses on how the economic benefits of the Rock Creek project compare with its costs, the cost effectiveness of the best management practices (BMP's), and how the project could have been made more economically efficient. Implications of the results for future programs are pointed out.

The major benefits from improvements in water quality in the project area will be improved recreational fishing on Rock Creek and reduced cleaning costs on irrigation feeder and drainage ditches. Some benefits from slightly lower maintenance costs for local hydroelectric plants also appear likely. However, the economic value of these water quality benefits appears to be less than the government costs of bringing about the improvements.

The project is producing other economic benefits that could result in total economic benefits exceeding costs if the project induces participating farmers to expand use of conservation tillage. Most of these benefits will go to the farmers whose costs of implementing BMP's are more than offset by a combination of reduced long-term crop yield losses when soil erosion is controlled, lower production costs with conservation tillage, and labor savings on irrigation. Expanding conservation tillage will improve upland and game habitat and could provide some hunting benefits to the public. An unmeasured but substantial benefit is the educational value of what is being learned and demonstrated about the cost effectiveness and onfarm benefits of conservation tillage on irrigated lands.

Conservation tillage appears the most cost-effective means of reducing sediment delivery to Rock Creek, while irrigation improvement structures appear the least cost effective. If greater knowledge and experience with conservation tillage had been available and if farmers could have been induced from the beginning to implement conservation tillage in place of irrigation structures, the project's benefits probably would have exceeded the costs. Irrigation improvements have been popular with farmers, because the improvements save labor, add to the appearance if not value of their farms, provide some tax deductions, and the government pays half the installation cost.

Off-farm economic benefits from water quality improvement are limited when no large-scale recreational or municipal uses are affected. For example, because Rock Creek does not feed directly into a reservoir with potentially large recreational use or affect urban water supplies, economic benefits from cleaning up the stream are smaller than they would otherwise be.

Even though off-farm economic benefits may be small, an economically justifiable project may be possible if the most cost-effective practices are emphasized. For example, additional

application of conservation tillage could result in total benefits of the Rock Creek project exceeding costs. Positive net benefits would likely have been the case if conservation tillage could have been implemented earlier instead of costlier structural practices.

Some rethinking about BMP implementation strategies may contribute to more cost-effective projects. Greater emphasis in the Rock Creek project to provide technical assistance and to educate farmers on the proper application and economic merits of conservation tillage may substantially increase their use of conservation tillage. Higher initial incentive payments for conservation tillage may have a positive effect and accelerate its adoption. At the same time, cost-share rates for the less cost-effective irrigation structures (which provide farmers with labor saving, farm value, and tax benefits) could have been lowered.

The Rock Creek project illustrates that total economic benefits may justify a project, but water quality benefits alone may not. If funding for future projects is based solely on achieving a water quality benefits goal, some future projects similar to Rock Creek with proportionally greater soil productivity benefits may not be funded. This suggests a need for consideration of dual objectives, and perhaps dual funding sources for some projects.

Economics of Controlling Sediment from Irrigation

An Idaho Example

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Introduction

This report summarizes the results and procedures of the economic evaluation of the Rock Creek, ID, Rural Clean Water Program (RCWP) project. The RCWP is an experimental program aimed at providing experience and insights for future nonpoint pollution control programs. The Idaho project is 1 of 21 projects in the Nation and is the only one that deals solely with irrigated agriculture. Greater details of the economic evaluation can be found in annual project progress reports (14,16) and in separate technical reports (17,18,25,26,27).1/

The physical and economic effects of RCWP are estimated by comparing the projected situation under RCWP with the before and without RCWP situations. Various scenarios are examined to determine cost effectiveness. These scenarios vary the implementation levels of best management practices (BMP's) and the length of time practices are maintained.

BMP's are being implemented under the RCWP in the project area primarily to improve the water quality in Rock Creek and Snake River. The principal pollutant is sediment from irrigation-caused cropland erosion. Lesser pollutants are bacteria from livestock operations and nutrients attached to sediment. Rock Creek had the worst water quality index of any stream in Idaho according to a 1981 environmental quality profile (15). The sediment load of Rock Creek is highly visible during the irrigation season when the muddy waters of the stream turn the Snake River brown at their confluence.

The economic evaluation has focused on the onfarm effects of the BMP's implemented or to be implemented under RCWP, the cost effectiveness of the BMP's and total project, the off-farm effects, and the benefits of the project compared with its costs.

1/ Underscored numbers in parentheses are cited in the References.

Also examined was how the project could have been made more economically efficient and what the implications are for future projects.

Principal procedures used in the economic evaluation of onfarm effects were spreadsheet analyses of individual participating farms and linear programming (LP) analysis of the total project (17,27). These procedures complemented each other and permitted a more complete evaluation to be made.

On-Farm Effects

The Rock Creek RCWP project area is located in south-central Idaho near the city of Twin Falls. The project area encompasses about 45,000 acres of the 203,000 acres in the Twin Falls irrigation tract. Of the 45,000 acres in the project area, 33,503 are cropland. Of the cropland, 28,159 acres (84 percent) were considered to critically need treatment for water quality purposes. Approximately 21,000 farm acres had been brought under contract through fiscal 1987, of which 17,299 acres were cropland (16).

Soils of south-central Idaho consist of Portneuf silt loam and closely related soils. Irrigation is practiced in the project area because average annual precipitation is only about 8.5 inches. The soil is suited to irrigated agricultural production because of its high productivity and high infiltration rates; however, the soil is also highly erodible. The original topsoil depth was about 15 inches over a lime-silica cemented hardpan. The upper ends of many fields are whitish in color because erosion has so reduced topsoil depth that plowing has fractured and brought portions of the hardpan to the surface. Reduction in topsoil depth has a negative effect on crop yields. About 75 percent of the fields in the RCWP area have white soils on their upper portions (6,7). Erosion in the furrows that traverse the fields creates the sediment and phosphorus problem in irrigation runoff.

Irrigation has been practiced in the Rock Creek area since 1905 with water supplied by canal from a diversion point on the Snake River at Milner Dam. Gravity irrigation from a system of dirt ditches served about two-thirds of the irrigated land before the RCWP project. Full implementation of RCWP contracts will reduce the use of dirt-ditch irrigation systems to about 22 percent of farm-field acres.

The major crops grown in the area include dry beans, wheat, corn, peas, sugar beets, and alfalfa. Dry beans, wheat, and alfalfa account for 90 percent or more of the crop acreage, while corn is grown on about 5 percent. A large number of crop rotations are used in the area. However, for the purposes of assessing the basic economic and physical effects of the RCWP project, a typical 6-year rotation is used. This rotation consists of beans, wheat, beans, wheat, alfalfa, and alfalfa.

BMP's Implemented Under RCWP

BMP's implemented through 1985 emphasized improved irrigation (BMP-13), filter strips (BMP-11), and end-of-field sediment retention structures (BMP-12) (tables 1-3). Conservation tillage (BMP-9) began to receive emphasis during 1986 when over 600 acres were placed into the practice and another 800 were contracted. Sediment basins and I-slots are the main sediment retention structures.

A goal of the project is to induce participants to extend their use of conservation tillage to 10,000 acres. Because conservation tillage on irrigated land is still a new practice, the long-term effects are not known. As conservation tillage becomes more widely adopted, some changes in the system will likely occur. Based on the favorable results of recent field tests within the Rock Creek area regarding income and erosion control effects and compatibility with irrigation, conservation tillage likely will be incorporated more and more into the farming system. It will take some time to overcome traditional ways of farming, especially the norm of clean-tilled fields. However, any farming system that provides an opportunity to reduce production costs, reduce yield declines, and improve farmer's income will receive serious consideration. Recent reports indicate that farmers are beginning to adopt the practice in increasing numbers (16).

Some water quality practices existed in the project area before RCWP (table 3). Sediment basins installed under other government programs served 304 acres. Improved irrigation systems, mostly concrete ditches and gated pipe, served nearly 6,920 acres.

Cost of Sediment Reduction

Installation costs (excluding technical assistance) of BMP's through 1986 range from zero cost per acre treated or benefited by irrigation water management (IWM) to over $200 per acre for improved irrigation structures (table 4). Minibasins and I-slots generally average around $20 per acre, while sediment basins cost over $33 per acre. Buried drains are the most expensive sediment retention practice, having an average installation cost $157 per acre.

Cost-share levels range from zero for IWM to 75 percent for sediment retention structures. Permanent vegetative cover, conservation tillage, and improved irrigation structures are cost shared at 50 percent.

Average cost-share payments are shown in table 4. Cost-share payments for most BMP's are one time, except for filter strips, minibasins, and I-slots, which are annual practices eligible for cost-sharing each year row crops come up in the field's rotation. Conservation tillage is eligible for up to 5 years of cost sharing. Contracts between the Agricultural Stabilization and Conservation Service (ASCS) and the farmer require the farmer to maintain an implemented practice for a specified period regardless

Table 1--Description of BMP's used in the Rock Creek, ID, project

BMP	Description
1. Permanent vegetative cover	Pasture and hayland planting, plus fence building to protect cover.
2. Animal waste management systems	Systems to prevent runoff from feedlots and other animal confinement areas.
9. Conservation tillage systems	Minimum-till involves chisel and subsoiling in place of moldboard plowing so as to leave at least 30 percent of the soil surface covered with residue. With no-till, the soil surface is left undisturbed prior to planting.
10. Stream protection	Involves fencing to protect streams from livestock.
11. Filter strips	Wheat and alfalfa strips planted at end of field to slow runoff and allow sediment deposition.
12. Sediment retention structures:	
Sediment basins	Impoundment structures located so field runoff is allowed settling time before flowing into the drainage ditch.
Minibasins	Shallow impoundment structures near field end just above the tail ditch. Minibasins allow settling time for field runoff.
I-slots	Narrow trenchlike excavations about 3 feet deep constructed in series in the tailwater ditch. These slots allow sediment removal from tailwater return flow.

Continued --

Table 1--Description of BMP's used in the Rock Creek, ID, project--Continued

BMP	Description
Buried drain systems	Consists of a buried drain pipe that replaces the tailwater ditch. Restores convex field ends and reduces sediment (5).
13. Improved irrigation:	
Concrete ditch and aluminum siphon tubes	Replace dirt head and feeder ditches to reduce water loss and provide better control of irrigation water.
Gated pipe	A water management technique that employs a gated pipe with spaced openings to feed water into the furrows. When placed midfield, the system splits the furrow run length and improves water management, while reducing erosion.
Land smoothing	Levels out the field and allows better irrigation coverage and control.
Side-roll sprinkler	A pressurized irrigation system consisting of a buried main line with surface fittings and risers that attach to movable laterals. It virtually eliminates runoff and sedimentation but involves high capital costs.
Irrigation water management (IWM)	A noncost-shared practice that usually results in an average reduction of two irrigations per year in addition to a stream-size reduction of 25 percent.

Table 2--Farmer participation in RCWP by BMP, Rock Creek, ID, project

BMP	Cumulative number of farmers implementing the BMP under RCWP by--				
	1983	1984	1985	1986 1/	End of project
			Number		
1. Permanent veg. cover	1	2	2	2	2
2. Animal waste mgt.	1	1	4	5	10
9. Conservation tillage	8	8	8	22	30
11. Filter strips	36	52	65	90	121
12. Sediment retention structures	47	75	89	98	139
13. Improved irrigation	65	96	116	132	163
Total participants 2/	101	146	168	177	182
Total farmers in area	272	272	272	272	272
			Percent		
Percentage participation	37	54	62	65	69

1/ Total is through Sept. 1, 1986.
2/ Total counts only once those who have more than one BMP. Excludes three farmers whose contracts were canceled before BMP implementation.

of the contract period, even though the cost-share may be paid when the practice is implemented.

Annual costs per acre show what the various BMP's actually cost the farmer before receipt of any cost-share, long-term yield change, or income tax benefits. All of the BMP's, except conservation tillage and IWM, have a net production cost ranging from $2 per acre for filter strips to $35 for midfield gated pipe (irrigation system costs are higher than dirt-ditch system costs). Conservation tillage and IWM reduce production costs below those of conventional systems and produce a net cost savings or benefit to the farmer. For conservation tillage, the savings are from reduced costs for labor and machine operation, compared with conventional tillage. For IWM, the savings are

Table 3--BMP's existing, implemented, and planned for the 177 contract farms under RCWP, Rock Creek, ID, project

BMP	Before RCWP	Implemented 1981-86	Still to be implemented	Total planned
		Acres		
1. Permanent cover veg.	--	16	130	146
2. Animal waste mgt.1/	--	6	16	22
9. Conservation tillage	--	628	818	1,446
11. Filter strips	--	3,323	1,497	4,820
12. Sediment retention structures:				
I-slots	--	981	529	1,510
Minibasins	--	255	--	255
Sediment basins	304	3,197	833	4,030
Buried drain	--	220	106	326
Sediment basin and filter	--	303	519	822
13. Improved irrigation:				
Concrete ditch	4,017	6,547	502	7,049
Gated pipe	2,424	4,404	1,736	6,140
Midfield gated pipe	305	1,048	--	1,048
Sprinkler	174	320	--	320
IWM	--	8,578	3,532	12,110
Total critical acres of cropland treated or served 2/	--	3/17,299	--	3/17,299
Total critical acres in project	28,159	--	--	--
		Percent		
Percentage of critical area treated	--	61.4	--	61.4

1/ Units are number of systems.
2/ Total counts only once acres treated or served by more than one BMP.
3/ Critical cropland acres under contract.

Table 4--BMP installation costs and cost-share conditions, Rock Creek, ID, project through fiscal 1986

BMP	Average installation cost per acre1/	Cost-share	Average cost-share paid 2/	Years cost-shared	Years of life	Change in annualized cost/acre3/
	Dollars	Percent	Dollars	-- Years --		Dollars
1. Permanent veg. cover	32.50	50	16.20	1	5-10	NA
9. Conservation tillage	36.15	50	15.27	3	1-50+	-33.00
11. Filter strips	4.62	75	2.70	4/	1	2.00
12. Sediment retention:						
Sediment basins	33.43	75	25.07	1	5	12.00
Minibasins	20.73	75	15.55	4/	1	8.00
I-slots	19.90	75	11.65	4/	1	9.00
Buried drain	156.91	75	117.68	1	10-25	15.00
13. Improved irrigation: 5/						
Concrete ditch	250.64	50	98.27	1	10-25	20.00
Gated pipe	196.67	50	65.81	1	10-25	26.00
Midfield gated pipe	202.59	50	94.86	1	10-25	35.00
IWM	0	0	.0	0	1	-4.50

1/ Average cost data based on actual expenditures to install practices.
2/ Average cost-share data based on actual cost shares paid.
3/ Production costs for practices other than conservation tillage are from Walker and others (26). Costs are before cost-share payment and are averaged over the entire rotation. The cost estimates for conservation tillage are from Thomas (23) and represent reductions in cost, compared with conventional tillage. Improved irrigation costs are above the $24 per acre cost for existing dirt-ditch irrigation.
4/ Cost sharing is done each year of contract when row crops come up in a field's crop rotation.
5/ Average costs are without any other practice combination.

from reduced labor because of a reduction in the numbers of irrigations per year, compared with conventional irrigation practices.

Short-Term Production Effects

Buried drains and minibasins can restore convex field-ends and, as a result, increase yields on lower ends of the fields. Sediment basins and grass waterways could remove some land from production, lowering crop production. Thus, the net short-term production effects of the BMP's applied to a particular farm or to the entire project depend upon the mix of BMP's.

Long-Term Yield Effects

Erosion occurring under pre-RCWP conditions of dirt-ditch irrigation would reduce long-term yields in the project area by 0.25 percent per year (1,2,4,6,7). The estimated difference in yield effects by slope category are -0.13 percent per year for slopes of 1 percent or less, -0.25 percent per year for fields with slopes greater than 1 percent but less than 2 percent, and -0.5 percent per year for fields with a slope 2 percent or more.

These yield declines from erosion may seem high by Midwest standards, but they are low for the Northwest region. Two dryland studies from the Northwest report yield declines of 25 percent over 50 years (3) and 50 percent over 90 years (19). These yield declines correspond to continuous annual rates of decline of 0.57 percent and 0.77 percent, respectively. Yield declines are more severe in the Northwest than in the Midwest because of lost moisture storage with soil erosion. With almost 70 percent of the 21-inch annual precipitation falling during the nongrowing season, the crops grown in the Northwest depend on antecedent soil moisture stored in the topsoil. Erosion of topsoil, rich in organic matter, reduces the moisture storage capacity of the soil and reduces yield. Moisture loss due to soil erosion is not a limiting factor for yield in southeast Idaho because its soil is irrigated. Yield declines in southeast Idaho still are greater than in the Midwest because of a restrictive lime-silica cemented hardpan in the subsoil. Consequently, the loss of topsoil means the loss of rooting zone and yield declines of about 0.13-0.5 percent per year, depending on field slope.

Yield declines in southeast Idaho can be translated into long-term economic losses by applying a standard rotation, initial crop yields, a set of prices, and a discount rate. The present value of the yield decline for the next 50 years is $66 per acre for fields with a 1-percent or less slope, $130 for fields of 1- to 2-percent slope, and $254 for fields with over a 2-percent slope. This means that a farmer with fields of 1- to 2-percent slope should be willing to spend up to $130 per acre to control erosion and prevent yield loss.

The estimated effects of various BMP's in reducing yield losses are shown in table 5. End-of-field practices, such as filter

Table 5--Estimated erosion reduction and long-term yield effects of BMP's in the Rock Creek, ID, project

BMP	Reduction in--		50-year economic impacts on fields with -- 3/		
	Erosion 1/	Crop yield loss 2/	0-1% slope	1-2% slope	Over 2% slope
	- - - - Percent - - - -		- - - - - - - - Dollars - - - - - - -		
			Present value of yield loss per acre		
No BMP's	0	0	66	130	254
			Present value of reduction in yield loss per acre		
Sediment retention structures	0	0	0	0	$0
Filter strip	0	0	0	0	0
Improved irrigation:					
Concrete ditch	25	25	17	33	64
Gated pipe	5	5	3	7	13
Midfield gated pipe	40	40	26	52	102
Side-roll sprinkler	100	100	66	130	254
Irrigation water management (IWM)	40	40	25	52	102
Conservation tillage:					
Minimum till	60	60	40	78	152

1/ Based on research by Brockway (2) and Carter (4). Estimates for IWM and conservation tillage are from Soil Conservation Service, Twin Falls, ID.

2/ Percentage reduction in long-term yield loss assumed to be the same as the reduction in on-field erosion.

3/ Rotation is beans, grain, beans, grain, hay, and hay. Initial yields are 23 cwt for beans, 5.5 tons for hay, and 110 bu. for grain. Prices are $20 per cwt for beans, $60 per ton for hay, and $3 per bu. for grain. Discount rate is 7.875 percent per year.

strips and sediment retention structures, do not reduce on-field erosion and have no effects on reducing long-term yield losses. Improved irrigation practices reduce erosion, from 5 percent for gated pipe to 100 percent for side-roll sprinklers. The reduction in yield loss is approximately the same as the reduction in erosion (21). Conservation tillage practices reduce erosion and yield losses by 60 percent or more, compared with conventional tillage practices.

Long-term economic benefits of reducing yield losses with various BMP's can be calculated by applying the percentage reduction in yield loss from the practice to the economic losses occurring without BMP's (see table 5). Projections of yield benefits over a 50-year period were made for each of the 177 participants in the project through August 1986. The projections were based on the assumption that all BMP's would be completed and used by the participants. Approximately 10 percent of the farms will have yield benefits of over $80 per acre and about 50 percent will have yield benefits of over $40 per acre, less than 15 percent of the farms will have yield benefits of less than $20 per acre. Farms with higher benefits per acre from erosion control are those with higher sloping fields.

Individual Participant Effects

Effects of RCWP on a typical farm in the project area, based on spreadsheet analyses, are shown in table 6. The farm has 100 acres of cropland in seven fields, ranging in size from 11-22 acres and with slopes of 0.5-3.5 percent. Four of the fields had dirt-ditch irrigation systems before RCWP, the other three had concrete ditches or gated pipes. None had any sediment control practices. Erosion rates ranged from 1.25-22.16 tons per acre per year.

Improved irrigation under RCWP was implemented on five of the seven fields. Dirt-ditch irrigation systems were changed to concrete or gated pipe systems in conjunction with irrigation water management. Sediment basins were installed on three of the seven fields. The improved irrigation practices reduced erosion rates by 60 percent on most fields. Installation costs of the BMP's totaled $13,000.

It is assumed in table 6 that the farmer maintains the improved irrigation practices over 50 years but discontinues 50 percent of filter strips and I-slots and 75 percent of sediment basins after his contract expires. With these assumptions, the farmer has a stream of increased costs partially offset by cost-share payments received and a stream of improved returns from reductions in yield loss. In table 6, the discounted increased costs exceed the discounted increased returns on four fields, resulting in a net loss. Two of the fields show discounted increased costs less than the discounted increased returns. Overall, the farm shows a net return of $1,022 or about $10 per acre.

Table 6--Effects of RCWP on a typical farm in the Rock Creek, ID, project

Item	Fields 1	2	3	4	5	6	7	Total farm
				Number				
Acres	11	12	12	10	15	18	22	100
				Percent				
Slope	.5	1	1	3.5	2.5	2	1.5	--
				Codes				
Irrigation practices: 1/								
Before RCWP	3	3	4	4	6	3	3	--
After RCWP	3	104	4	104	106	104	104	--
Sediment practices: 2/								
Before RCWP	0	0	0	0	0	0	0	--
After RCWP	0	1	6	6	6	1	2	--
				Tons per acre per year				
Sediment production rate:								
Before RCWP	1.25	1.25	1.25	22.16	12.14	5.51	5.51	3/668
After RCWP	1.25	.38	.12	2.22	1.21	1.65	1.32	3/119
				Dollars				
Installation costs:								
Irrigation practices	0	3,000	0	0	0	4,500	5,500	13,000
Sediment practices	0	24	144	120	180	36	198	702
50-year changes in costs with tax considerations: 4/								
Irrigation systems costs	0	2,220	0	0	0	3,330	4,070	9,620
Sediment practice costs 5/	0	87	285	238	356	130	715	1,811
Less cost-share payments	0	-1,555	-108	-90	-135	-2,330	-3,195	-7,413
Total change in costs	0	752	177	148	221	1,130	1,590	4,018
50-year changes in returns 4/ (reduction in yield loss)	0	317	103	1,016	1,524	936	1,144	5,040
50-year net change in returns after income tax 4/	0	-435	-74	868	1,303	-194	-446	1,022

-- = Not applicable.

1/ Irrigation system codes: 3 = dirt ditch, 4 = concrete ditch, 104 = concrete ditch with irrigation water management, 6 = gated pipe, and 106 = gated pipe with irrigation water management.

2/ Sediment practice codes: 0 = no practices, 1 = filter strips, 2 = I-slots, 6 = sediment basins.

3/ Tons per year.

4/ Discounted dollars.

5/ Allows discontinuation of 50 percent of filter strips and I-slots and 75 percent of sediment basins after contracts expire.

Source: Spreadsheet analysis (17).

Similar projections, based on spreadsheet analyses, were made for all 177 participants in the RCWP project through August 1986 (10). Over half of the farmers will gain economically from participation in RCWP. Values range from a benefit of $108 per acre to a cost of $277 per acre. The farmers that show negative benefits from participation in RCWP are the ones who installed

costly structural measures and have to maintain these systems without further cost sharing. This analysis does not include any short-term yield benefits that may occur if convex field ends are restored or if filter strips are harvested and probably underestimates the number of farmers gaining economically from RCWP. The implementation of additional minimum tillage, with its reduction in cost over conventional tillage and its long-term yield benefits, would further increase the number of participants benefiting economically.

Aggregate Effects

Total onfarm effects of 177 participants implementing all contracted BMP's are shown in table 7. The benefits after taxes to farmers as a group from participating in the RCWP project exceed the costs of putting in the BMP's by $400,000-$600,000. Costs are highest and net returns lowest when farmers maintain, without further cost sharing, all irrigation and sediment control practices. If farmers partially phase out filter strips and I-slots by 50 percent and sediment basins by 75 percent after contract expiration, as is happening in the nearby LQ Drain Watershed (8), they will save costs and increase returns.

Even higher net benefits to participants, $2.3-$2.5 million, will occur if the project successfully promotes the adoption of 10,000 acres or more of minimum tillage in addition to the practices already under contract. The additional acres of minimum tillage would require contract modifications, but the farmers would benefit from reduced costs of tillage and reduced long-term yield losses due to erosion.

COST EFFECTIVENESS OF THE BMP'S

The cost effectiveness of the various BMP's in reducing sediment from irrigation ranges from a 5-percent reduction for gated pipe to 100-percent reduction for side-roll sprinklers (table 8). Relative cost effectiveness of each practice can be measured by dividing the annual cost per acre by the percent reduction in sediment delivery to get the cost per percent reduction in sediment.

The most cost-effective BMP is conservation tillage. This BMP actually reduces farmers' costs of production and, at the same time, reduces sediment by 60 percent or more. Next in cost effectiveness is irrigation water management, followed by filter strips and sediment retention BMP's. Least cost effective in reducing sediment are improved irrigation practices, particularly gated pipes. With the increased emphasis on trying to get farmers to adopt conservation tillage, it is expected that the overall cost effectiveness of the project in terms of sediment reduction will increase.

Table 7--Aggregate onfarm economic effects of implementing the Rock Creek RCWP project, 50-year period, 1981-2030. 1/

Item	RCWP as contracted	RCWP with minimum tillage on -- 10,000 acres 2/	All acres (optimizing) 3/
		Number	
Participants	177	177	177+
		Acres	
Cropland treated	17,299	21,119	33,503
		Million dollars 4/	
Economic benefits to farmers:			
Cost share payments received	1.2	1.3	1.1
Short-term yield benefits 5/	.3	.3	0
Long-term yield benefits 6/	.7	1.6	3.4
Tillage cost reduction	.3	1.2	3.3
Total before taxes	2.5	4.4	7.8
Tax savings on BMP's 7/	.9-1.0	.9-1.0	0
Total after taxes	3.4-3.5	5.3-5.4	7.8
Economic costs to farmers:			
Irrigation systems costs	2.1	2.1	0
Sediment reduction costs	.7-1.0	.7-1.0	0
Total costs	2.8-3.1	2.8-3.1	0
Net benefits to farmers after taxes	.6-0.4	2.5-2.3	7.8

1/ First number in range reflects participants phasing out 50 percent of filter strips and I-slots and 75 percent of sediment basins to save costs and increase profits after expiration of contracts. Second number in range reflects all contracted BMP's fully implemented and maintained.

2/ Adds 10,000 acres of minimum tillage starting with steepest land first.

3/ Maximizes farmers' income while achieving at least a 60-percent reduction in sediment. The linear programming model selected minimum tillage for application on all acreage except alfalfa.

4/ Future dollars discounted to present values at a rate of 7.875 percent per year and converted to 1986 dollars.

5/ Based on results of linear programming analysis (27).

6/ Reductions in long-term yield loss are based on estimates of 0.13, 0.25, 0.5-percent per year yield loss due to erosion on slopes of 1 percent or less, between 1 and 2 percent, and greater than 2 percent, respectively.

7/ Tax savings on long-term practices assumed a first-year tax credit of 10 percent and a marginal tax rate of 21 percent.

Table 8--Average cost effectiveness of BMP's in the Rock Creek RCWP project

Practice	Change in average cost per acre 1/	Average effectiveness in reducing 2/		Cost per percent reduction in sediment 2/
		Erosion	Sediment delivery	
	Dollars	-- Percent --		Dollars
Filter strips	2.00	0	55	0.04
Sediment retention:				
I-slots	9.00	0	75	.12
Minibasins	8.00	0	85	.09
Sediment basins	12.00	0	90	.13
Buried drains	15.00	0	90	.17
Improved irrigation:				
Concrete ditch	20.00	25	25	.80
Gated pipe	26.00	5	5	5.20
Midfield gated pipe	35.00	40	40	.87
Side-roll sprinkler	48.00	100	100	.48
IWM	-4.50	40	40	-.11
Conservation tillage:				
Minimum till 3/	-33.00	60	60	-.55

1/ See Walker (25). Cost figure is the total of variable and fixed costs averaged across principal rotations over the life of the practice. Costs for improved irrigation and conservation tillage BMP's are costs above those for conventional irrigation ($24) and tillage practices.

2/ See Brockway (2) and Carter (4). Effectiveness of IWM and conservation tillage are estimates by the Soil Conservation Service, Twin Falls, ID.

3/ See Thomas (23).

Cost Effectiveness of the Project

Government costs of the Rock Creek project will total about $2.9 million if the project is fully implemented as currently contracted (table 9). If the project is successful in modifying the contracts and getting farmers to increase their use of minimum tillage to 10,000 acres, costs will reach about $3.3 million, assuming no increase in cost-share rates. Cost-share payments to participating farmers account for 60-65 percent of the cost, technical assistance accounts for 31-33 percent, and the balance is spent on information and education programs related to RCWP.

Because farmers' costs of implementing BMP's under RCWP are more than offset by tax, yield, and other onfarm benefits, their net benefits are included in project benefits and no entry is made on the project cost side.

The project's effectiveness is indicated by the reduction in sediment delivered to Rock Creek. This information is based on results of a linear programming model (27). The model predicts that the project, as contracted, will reduce annual sediment delivered by an estimated 13-24 percent, depending upon the extent to which farmers phase out filter strips, I-slots, and sediment basins to save cost after expiration of the contracts. If the project successfully induces farmers to further adopt up to 10,000 acres of minimum tillage, a sediment reduction of 45-56 percent is predicted by the model.

In addition to the BMP's implemented through 1986 and those planned through 1991, some practices were implemented by nonparticipants of the RCWP program. Some nonparticipants may have tried these practices because of the RCWP publicity. The estimated reduction in sediment delivery to Rock Creek because of BMP implementation on noncontract acres is 7 percent. This reduction added to the reduction from BMP's on contract acres totals 20-31 percent, depending on how much phaseout of BMP's occurs. Successful promotion of minimum tillage use on up to 10,000 acres of contracted land could stimulate use of the practice on noncontracted lands. If so, total sediment reduction could exceed 60 percent, compared with the situation before the project.

A rough measure of the cost effectiveness of the project can be obtained by dividing total government cost by the estimated percentage reduction in sediment that will occur (table 9). It will cost $79,000-$146,000 per percent reduction in sediment loading to implement all BMP's currently under contract at Rock Creek. Expansion of minimum tillage use to 10,000 acres, if it can be achieved, will greatly improve the cost effectiveness of RCWP to $37,000-$46,000 per percentage point reduction in sediment delivered.

If minimum tillage had been adopted initially instead of costly structural measures, the RCWP program costs could have been

Table 9--Costs and effectiveness comparisons for the Rock Creek RCWP project

Item	RCWP as contracted	RCWP with minimum tillage on-- 10,000 acres 1/ 2/	All acres (optimizing) 3/
		Acres	
Acres treated	17,299	21,119	33,502
		Million dollars	
Costs:			
RCWP cost share payments	1.8	4/2.2	5/1.7
RCWP technical assistance 6/	.9	.9	.9
RCWP information and education 6/	.2	.2	.2
Total RCWP cost--			
Actual dollars	2.9	3.3	2.8
Discounted 7/	1.9	2.1	1.8
Effectiveness (reduction in sediment delivery)		Percent	
Contracted acres from BMP's 8/	13-24	45-56	60-75
Noncontracted acres	7	7	7
Total reduction	20-31	52-63	67-82
		1,000 dollars	
Government cost per percentage reduction in sediment delivery from BMP's on contracted acres	146-79	46-37	30-24

1/ First number in range reflects participants phasing out 50 percent of filter stripts and I-slots and 75 percent of sediment basins to save costs and increase profits after expiration of contracts. Second number in range reflects all contracted BMP's fully implemented and maintained.
2/ Adds 10,000 acres of minimum tillage starting with steepest land first.
3/ Maximizes farmers' income, while achieving at least a 60-percent reduction in sediment. The linear programming model selected minimum tillage for application on all acreage except alfalfa.
4/ Based on an additional 8,554 acres of minimum tillage at a 3-year total cost share of $51 per acre ($17 per year).
5/ Based on 33,502 acres of minimum-till at $51 total cost share per acre.
6/ Assumed to be approximately the same under all alternatives.
7/ Actual projected expenditures discounted by 7.875 percent per year and expressed in 1986 dollars.
8/ Based on results of linear programming analysis which reflects sediment reduction from BMP implementation with other factors constant. May differ from monitoring results that reflect sediment reduction from many factors besides BMP's, such as stream bank erosion and weather and cropping variations (27).

lowered and cost effectiveness increased (potentially reaching a 75-percent reduction in sediment delivered), for a cost effectiveness of $24,000 per percent reduction in sediment delivered. Monitoring data now being collected on sediment in Rock Creek, after adjustment for changes in rainfall and cropping patterns, should be used to verify actual effectiveness of the project.

Off-Farm Effects

Sediment and nutrients in Rock Creek clearly impaired its uses for recreational fishing. Sediment in irrigation return flows was silting up ditches, canals, and drains. Removal of this sediment required dredging and cleaning. Other alleged impairments attributed to erosion in the project area and sediment in Rock Creek were added power generation costs, added water treatment costs, decreased property values, and reduced wildlife habitat. All these possible impairments were evaluated.

Recreational fishing benefits through the year 2030 from the restoration of Rock Creek into a quality trout fishery were estimated by Garifo and Gum (13) to be worth $411,000 in 1986 dollars. This estimate was based on an increase in fishing days per year from 500 in 1981 to 8,000 in 2030 at a value per fishing day of $7.94. A more recent Forest Service study (22) on the value of fishing in Idaho places a value of $14-$42 per day, depending upon the valuation method, for fishing on the Snake River in the same general area as Rock Creek. By using the average value of $28, potential benefits are projected to be $1.4 million during the 1981-2030 period.

If BMP's totally eliminated the need for dredging and cleaning irrigation drains and laterals, the annual cost saving could total $37,276 or $1.02-per-field-acre. This estimate by Walker and others (25,26) is an upper bound of the potential benefits. If sediment is reduced 50 percent and dredging and cleaning costs also are reduced 50 percent to a total of $18,638 annually, the estimated value of 50 years of such reduced dredging and cleaning costs would be about $300,000.

Reduction in power generation costs on the Snake River as a result of lower sediment delivery by Rock Creek is estimated to be negligible (25,26). This conclusion is based on the fact that the first power generation plant on the Snake River is 20 miles downstream and is a run-of-river facility. The first major reservoir powerplant is 120 miles downriver. Given an understanding of the sediment transportation-channel erosion process, the reduced sediment in the Rock Creek likely will be offset by increased channel erosion and will have little effect on power generation costs on the Snake River.

In 1983, a small scale hydroelectric plant began operation on Rock Creek. Another plant is under construction. These plants are vulnerable to sediment damage. The manager of the first plant reports that the heavy sediment load in Rock Creek causes extra wear on the impellers, shaft sleeves, and seal rings (12). Much of this damage is due to bedload (heavy sand and gravel from the bed of Rock Creek), but some damage is due to finer sediment particles contributed by erosion and runoff from agricultural lands. We could not obtain data to estimate the dollar value of benefits to the hydroelectric plants because of reduced agricultural sediment. Even so, the benefits from the two small plants probably will be insufficient to change the overall benefit-cost relationship of the project.

Water treatment cost reduction does not exist because Rock Creek is not used to supply municipal water. Also, no effect on property values was projected because of the relative scarcity of homesites close enough to Rock Creek to be affected by the water quality of the stream.

LaPlant and others (20) estimated that the RCWP project would not have a significant effect on upland game habitat. However, significant benefits may be achieved in the future if use of minimum-tillage practices is increased. These practices would provide ground- cover and increased food for game birds (mostly pheasants and partridge) during winter months. If 10,000 acres (about a third of the cropland) are put into minimum tillage, hunting benefits could accumulate to $200,000 by the year 2030. Use of minimum tillage on nearly all cropland could increase accumulated hunting benefits to $500,000 by the year 2030.2/

The off-farm benefits of the project are projected to total between $400,000 and $1.5 million, depending upon the extent to which minimum tillage becomes implemented and other practices are maintained (table 10). The major off-farm benefit in all cases will likely be improved fishing on Rock Creek. Since initiation of the project, fish populations have expanded and native trout species have returned (9,10,11).

Benefits Versus Costs

As contracted in 1986, total economic costs of the project over the 50-year period (1981-2030) will exceed total economic benefits (table 10). Total benefits would exceed costs if the project is successful in getting participants to adopt 10,000 acres or more of minimum tillage.

Off-farm benefits alone, particularly water quality benefits, will probably not exceed project costs, even with 10,000 acres of minimum tillage. Given the limited potential for off-farm benefits (no major lakes or reservoirs affected or large population centers to use the cleaner water), project costs would have to be reduced to make the project more economically justifiable from a water-quality perspective. In retrospect, this might have been achieved by less early emphasis on costly structural practices and greater emphasis on conservation tillage.

2/ These estimates assume that having a third of the project area in conservation tillage would increase pheasants and partridge populations enough to stimulate a 50-percent increase in hunter days, and that full use of conservation tillage would permit a 100-percent increase in hunter days. The 1985 value of pheasant and partridge hunting in the project area was about $75,000, based on about 3,000 hunter days (11 percent of the total for Twin Falls County) at $25 per day (28).

Table 10--Benefit-cost comparisons for the Rock Creek RCWP project, 50-year period (1981-2030).

Item	RCWP as contracted	RCWP with minimum tillage on-- 10,000 acres 1/ 2/	All acres 3/
		Million dollars 4/	
Benefits:			
Off-farm--			
Improved fishing	0.3-0.5	0.8-1.0	1.4
Improved hunting	0	.2	.5
Reduced ditch cleaning	.1	.3	.4
Subtotal off-farm	.4-.6	1.3-1.5	2.3
Onfarm benefits before taxes (net) 5/	(.3-.6)	1.6-1.3	8.0
Total benefits	.1-0	2.9-2.8	10.3
Government RCWP costs 6/	1.9	2.1	1.8
Net benefits:			
Off-farm benefits, less costs	(1.5-1.3)	(.8-.6)	.5
Total benefits, less costs	(1.8-1.9)	.8.-7	8.5
		Ratio	
Benefit/cost ratios:			
Off-farm benefits/costs	.2-.3	.6-.7	1.3
Total benefits/costs	.05	1.4-1.3	5.7

1/ First number in range reflects participants phasing out 50 percent of filter strips and I-slots and 75 percent of sediment basins to save costs and increase profits after expiration of contracts. Second number in range reflects all contracted BMP's fully implemented and maintained.
2/ Adds 10,000 acres of minimum tillage starting with steepest land first.
3/ Maximizes farmers' income while achieving at least a 60-percent reduction in sediment. The linear programming model selected minimum tillage for application on all acreage except alfalfa.
4/ Streams of benefits and costs are discounted (7.875 percentage rate) and converted to 1986 dollars.
5/ See table 7 for greater detail.
6/ See table 9 for greater detail.

An optimizing run made with the linear programming model depicts the potential for an economically efficient project, given the information now known. Implementation of minimum tillage instead of other less cost-effective practices, would have increased water quality and other off-farm benefits while, at the same time substantially increasing onfarm benefits (production cost savings and long-term yield preservation). If necessary, higher incentives could have been paid for adoption of minimum tillage during the initial years, and still have maintained costs below off-farm benefits.

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